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MATHEMATICS AND THE SCIENCES[1]

By Professor C. V. NEWSOM

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A CLOSE inspection of the history of mathematics and that of physical science reveals the mutual dependence of the two fields of thought. At times mathematical development has been definitely stimulated by the needs of science; at other times scientific progress has been extremely rapid because of the availability of the necessary mathematical devices. It is interesting to observe, however, that serious reflection upon the actual relation of mathematics to the sciences has awaited the twentieth century. Such consideration, stimulated by a better understanding of the nature of mathematics, needs greater publicity, for it is the immediate cause of the mathematizing of parts of science previously untouched by mathematical treatment. This paper, then, will briefly review some of the factors which are of importance in any attempt to understand the relation of mathematics to the sciences. Implicit in the discussion is a broad definition of mathematics; my only apology for such a point of view is that it is the modern one.

Certainly it is true that a natural science originates with inductive procedures. The inspection of many similar situations in an effort to perceive those constant principles to be designated as laws must always remain fundamental. However, a time comes in the life history of a science when such methods are no longer adequate. Lapicque[1] has expressed the thought in the following words:

[1] Address of the retiring president of the Southwestern Division of the American Association for the Advancement of Science, Lubbock, Texas, April 30, 1941.

[1] L. Lapicque, "L'orientation actuelle de la Physiologie," in *L'orientation actuelle des sciences* (Paris, 1930). The translation employed here was given by C. N. Moore in SCIENCE, v. 81: p. 31, 1935.

Formerly, not very far back in the history of humanity, let us say a century ago, almost everything was unknown concerning the physiology in the labyrinth of the living body. Magendie said: "I wander around there like a rag picker, and at each step I find something interesting to put in my basket." This maxim horrified my teacher, Dastre, who was wont to say: "When one doesn't know what he is looking for, he doesn't know what he finds." For him the ideal of physiological research would have been to conceive in the quiet of one's study a theory explaining such and such a phenomenon, known but not understood, then to find, still by meditation, the experiment capable by a yes or a no, of proving or disproving the theory. One would come then some morning to the laboratory, and that very evening the matter would be decided. These two tendencies, each in its amusingly exaggerated form, seem to me to serve the purpose of characterizing the temperament of naturalists and that of physicists. In proportion as physiology develops, the discoveries for rag pickers become more rare, and the possibility of working as Dastre dreamed is approaching.

In the preface of Woodger's epoch-making book entitled "The Axiomatic Method in Biology,"[2] he explains his attitude similarly as follows:

> In every growing science there is always a comparatively stable, tidy, clear part, and a growing, untidy, confused part. I conceive the business of theoretical science to be to extend the realm of the tidy and systematic by the application of the methods of the exact or formal sciences, *i.e.*, pure mathematics and logistic.

What, then, is the method of mathematics? Essentially, it is typified by an organization of the propositions of a science into those which are to be accepted as primary or basic and those which may be logically deduced from them. The former propositions are known as the axioms of the science, the term axiom signifying only that the statement thus designated is not proved within the system, whereas the latter propositions are called the theorems or secondary propositions.

To a great extent the original choice between axioms and secondary propositions is arbitrary. The axioms should constitute a consistent set of statements; moreover, they should be entirely ample for the deduction of the remaining propositions of the system when the rules of inference accepted as an adjunct to the system are applied. If a proposition is found among the set of axioms which is a logical consequence of other axioms, its status, of course, should be changed to that of a secondary proposition. Also, it is frequently possible to keep the mathematical organization of a science intact by replacing a collection of the axioms by a smaller number of more primitive statements; sometimes such new axioms may not have been accepted previously as propositions within the science. As a result of this latter process, it is often true that some axioms will be of such a nature that their truth-property can not be studied directly through the medium of empirical procedures.

The subject-matter symbols of a science organized in the manner just described may not be part of the usual language of the science. In fact, the language of most sciences was not introduced for the purpose of facilitating the construction of a logical structure, and progress toward that end virtually demands some use of the symbolism of mathematics and logistic. The success of Woodger in accomplishing a rather elegant mathematical organization of some portions of biology is due partly to his use of a special set of symbols augmented by the symbolism of the "Principia Mathematica" of Whitehead and Russell.

When a logico-deductive system of the type under consideration includes no interpretation of the subject-matter symbols, it becomes a structure in pure mathematics. Of course the rules of inference are valid, and actually are more readily applied, if the basic set of axioms is uninterpreted. It is important to note, however, that the propositions within such a system assert nothing about any part of science, for they convey no meaning. In this connection we recall the familiar statement of Russell that "Mathematics is the subject in which one never knows what he is talking about nor if what he says is true." It is even doubtful that a typical non-assertive statement in mathematics should be characterized as a proposition; it merely has the form of a proposition. Also, any notion of truth-property vanishes from the system, and the concept of consistency becomes the important factor.

So, from some points of view, a mathematical structure may not possess meaning, but it certainly has form. In fact, a structure in pure mathematics may be likened to a pattern or a model or, perhaps better, to a skeleton. It has been constructed by an expert who knows how to link propositions through the use of the rules of inference, the chain starting with a few propositions which are taken as primitives. Charles Sanders Peirce, the Harvard logician, recognized this years ago when he said, "I consider that the business of drawing demonstrative conclusions from assumed premises, in cases so difficult as to call for the services of a specialist, is the sole business of the mathematician." Again he stated, "The business of the mathematician is to frame an arbitrary hypothesis, which must be perfectly distinct at the outset, so far, at least, as concerns those features of it upon which mathematical reasoning can turn, and then to deduce from this hypothesis such necessary consequences as can be drawn by diagrammatical reasoning."

[2] J. M. Woodger, "The Axiomatic Method in Biology," p. vii. London: Cambridge University Press, 1937.

Through the ages, mathematicians have constructed many of the symbolic skeletons which constitute the field of pure mathematics. Some of them are only superficially different, but that fact is irrelevant to this discussion. Suffice it to say here that there has been a frenzy in mathematical circles in recent years; the pace in mathematical research has become faster and faster as new mathematical structures are created and old ones perfected or extended. Such matters are of interest to the scholar, but the writer of this paper must insist that mathematics would become a dead subject and mathematicians an economic liability if the structures of pure mathematics should cease to be of great importance in the sciences.

The task of covering a mathematical skeleton with the flesh which is the substance of a science is not always simple. It requires, first of all, the discovery of a mathematical structure which possesses an axiomatic basis capable of becoming the foundation of the science under consideration when the subject-matter symbols are properly interpreted. In other words, a mathematical structure becomes a system in theoretical science when the subject-matter symbols are properly particularized in meaning. When such precise correspondence, as is implied here, is attained between the fundamentals of a mathematical structure and the primitives of a science, the same definite correspondence is maintained throughout the two systems; that is, the system in pure mathematics and the science organized through its use are identical in form or are isomorphic. In view of the extensiveness of most mathematical structures which are available, success in fitting a mathematical structure to the data of a science may immediately increase knowledge relative to that science many times over. Scientific discoveries which have attended the use of the method have been little short of astounding.

At this point a brief consideration of a very simple mathematical system might be of interest. It should be recalled that meaning is not a necessary ingredient, so the uninitiated may regard a mathematical system as mere jargon. The symbolic system which characterizes "simple order" is of frequent use to mathematicians, and is concerned with a set of elements, A, B, C, etc., and a relation designated by the symbol R. There are three axioms; namely,

1. If A is different from B, then either A R B or B R A.
2. If A R B, then A is different from B.
3. If A R B, and B R C, then A R C.

Not many propositions can be logically deduced from these axioms, but a typical consequence is the proposition,

4. A R B and B R A is false.

An application of the mathematics of simple order may be found in biology when studying the procreation of yeast cells. A new yeast cell first appears as a bud upon the parent cell. The young cell ultimately separates from its parent, becomes mature, and then begets new cells, one at a time. Every cell has essentially the same kind of a life history. If, now, some one cell is designated by a letter of the alphabet exclusive of R, its first offspring by another letter, the first progeny of the second lettered cell by another letter, and so on, the axioms just given will be satisfied if R is assigned the interpretation, "is an ancestor of." In fact, the axioms become

1. If yeast cell A is different from yeast cell B, then either A is an ancestor of B or B is an ancestor of A.
2. If A is an ancestor of B, then A is different from B.
3. If A is an ancestor of B, and B is an ancestor of C, then A is an ancestor of C.

Now by referring to the mathematical proposition 4 which was deduced as a logical consequence of the original axioms, the valid assertion may be made that

4. A is an ancestor of B and B is an ancestor of A is false.

Such a conclusion is obvious, for the situation studied is a simple one, and the mathematical system employed is elementary. Perhaps, however, persons unfamiliar with mathematical studies can now partially appreciate how a similar technique can be of value in the study of complicated situations when involved mathematical systems are necessary.

Among the numerous other applications of the mathematics of simple order is the specific ordering of a set of temperature readings. This may be accomplished by employing the letters, A, B, C, etc., to denote various temperatures, and by giving to R the interpretation, "is higher than."

The studied use of mathematical methods in science is not new. Archimedes organized a treatise upon some aspects of mechanics before the second century, B.C., in which the deductive procedures of mathematics are brilliantly displayed. Archimedes had been schooled in Euclidean methods while at Alexandria, and his contributions to geometry and mechanics are a manifestation of his rigorous training. The first book of his treatise on mechanics entitled "On Plane Equilibria or Centres of Gravity of Planes" contains fifteen propositions deduced from seven axioms, and demonstrations are given for the determination of various centers of mass which are virtually identical with those still employed in elementary books upon mechanics. His second book of ten propositions extends the work of the first book to more difficult consideration.

It appears that Sir Isaac Newton believed in the possibility of inventing a theoretical science which

would be of universal application to the study of the physical universe. In attempting to organize his science, he assumed mass points of invariable mass to be the basic entities. He then proceeded to the consideration of the necessary fundamental propositions involving such mass points. The foundation which he conceived is familiar to every student of physical science; however, it is incomplete from a mathematical point of view.

In 1788, Lagrange published his analytic mechanics. For the first time, a science of mechanics was systematized by the use of mathematical methods. In the preface to his masterpiece, Lagrange wrote, "No diagrams will be found in this work. The methods which I expound in it demand neither constructions nor geometrical or mechanical reasonings, but solely algebraic operations subjected to a uniform and regular procedure." Within his organization he explicitly stated a hypothesis, for example, upon which the well-known principle of the composition of forces is founded. Throughout the treatment, Lagrange insisted that the principles of mechanics are developed from assumptions, and, apparently, he did not believe that such principles form a system of absolute truths discovered by some group of scientists working in partnership with the Deity.

In modern times, the use of the mathematical method in science is becoming common. Some parts of the axiomatic basis for the theory of relativity are probably better known than are other aspects of the theory. The beginning student in mechanics should be given the opportunity to read Huntington's modern work entitled "The Logical Skeleton of Elementary Dynamics,"[3] for the mathematical approach in Huntington's development is quite satisfying. The economist with ample background is usually impressed with the possibilities of which he has a glimpse in some modern mathematical studies upon economic problems.[4] The work of Woodger in biology has already been mentioned. The number of such studies is rapidly increasing, and a definite impetus has recently been given to the careful consideration of the organization of a science by the early publications of the committee sponsoring the "International Encyclopedia of Unified Science."[5]

It seems foolish to the mathematician for any one to advocate that the use of the mathematical method is the certain cure for all the ailments of science. Yet achievements resulting from its use have been so notable that some men have made the doubtful declaration that what Descartes dreamed is true: that it is possible to arrive at a complete mechanical interpretation of the world in the exact terminology of mathematics. This expresses the attitude of the extreme mechanist. Irrespective of one's point of view upon this controversial question, all will admit the potency of the mathematical method when circumstances are such as to justify its use. In fact, many persons, even scientists, have developed a certain awe of mathematics. For them it may be surprising to read Bridgman's statement, "It is the merest truism, evident at once to unsophisticated observation, that mathematics is a human invention."[6] In other words, one of man's best-known devices for interpreting nature possesses the same elements of strength and weakness that belong to man himself. The significance of this fact is closely related to the underlying philosophy of all science.

The subject-matter of any science is a collection of sense-experiences which originally appear as a chaotic variety. In attempting to interpret such a collection of experiences, science seeks some pattern to which they appear to conform. Thus the recognized object of science is the development of mechanisms, a mechanism being simply a man-made schema or model which purports to relate a set of natural phenomena in a rational manner. A mechanism may be pictorial, as is the conventional atomic model portrayed to elementary students of physical science, or it may be diagrammatic like the device employed by the organic chemist to display the manner in which a large number of atoms may cling together to form a complex molecule. So, just as the architect's blue-print possesses a correspondence to the finished house, the mechanism of the scientist is made to correspond to some part of nature.

A mathematical structure when applied as a correlating agent to the data of a science merely becomes a mechanistic device, and must be regarded as such by the scientist. It is the belief of many, however, that the mathematical mechanism has merits which others do not possess. For example, deductive reasoning as rigidly employed in mathematics is the only means yet developed for isolating hidden assumptions and for following the subtle implications of the various hypotheses. Moreover, the basic entities of a science are conveniently recognized as those which are represented by subject-matter symbols that are not explicitly defined within the mathematical system employed; in fact, such symbols are given an implicit definition by the set of primitive statements in which they occur.

[3] E. V. Huntington, *Amer. Math. Monthly*, 24: 1–16, 1917.

[4] Note, for example, G. C. Evans, "Mathematical Introduction to Economics." New York: McGraw-Hill Company, 1930.

[5] Note Volumes I and II. "Foundations of the Unity of Science," edited by Otto Neurath. Chicago: University of Chicago Press, 1938.

[6] P. W. Bridgman, "The Logic of Modern Physics," p. 60. New York: Macmillan Company, 1927.

The systematization which mathematics gives to a science is never static, and the science thus organized takes on a directed growth. Some investigators will always be concerned with the reorganization of the axiomatic base of the system, and especially with the possibility of decreasing the number of the axioms. Other students of the science will be making additional deductions from the accepted body of propositions, and new propositions obtained thereby will furnish the suggestion for more experimentation. In fact, the mathematization of a science must never be regarded as a substitute for experiment, for experimentation is continually necessary for confirmation of the theoretical structure. One experimental result contrary to that predicted by the mathematical theory may be sufficient to cause a thorough revision of the theory, or perhaps relegate the whole thing to the grave of false hopes. Of course, many factors must be considered before a theory is actually discarded; for instance, a simple theory furnishing quite approximate results may be employed in preference to a very complex theory which is considerably more accurate in its interpretation of nature.

There is a strange fact about all these mechanistic devices which have been invented and employed by man in his effort to comprehend nature. They are first called laws of science, then, perhaps, laws of nature. After a while man is inclined to forget that they are products of his own imagination, and comes to believe that they are real and a part of creation. This fact has been responsible for many unfortunate attitudes and points of view. So some comments pertaining to the true relationship between a mathematical theory and that portion of nature which it is designed to interpret may be appropriate.

First of all, it must be emphasized that modern science recognizes the ultimate complexity of nature, and any theory which science may employ is too simple to have exact structural similarity to any part of nature. The mathematician may seek a linear formula that best represents the trend of a random set of points which are distributed, however, so as to suggest a straight line; in like manner, the scientist systematizes his study by the use of a mathematical pattern which can reflect only the general behavior of the data of his science. Moreover, it is doubtful that there is a unique theory to be sought by the scientist laboring in any field, for as Bliss[7] has said, "There are always more mathematical theories than one whose results depart from a given set of data by less than the errors of observation." The Ptolemaic and Copernican theories of the solar system furnish illustrations of two essentially different theories which, after slight modification of the former, describe equally well the behavior of the planets. The modern popularity of the Copernican theory is due chiefly to its relative simplicity.

A serious misunderstanding in regard to the mathematizing of science is apparent in the writings of some popularizers of scientific theory. In many instances, such writers read into nature a lot of fantasy which has its origin in some mathematical property of the theory under discussion rather than in the data from nature which the theory is designed to systematize. Of course, an adequate discussion of such matters must penetrate deeply into the subject of scientific methodology. An example of this type of misunderstanding is to be found in the insistence of some persons that the universe is finite, simply because the finite geometry of Riemann has been used with considerable success as a correlating agent of the data of the astronomical universe. Similarly, there is no justification for stating that continuity is a property involved in a set of data when a calculus of continuous functions has proved valuable in studying it. Many mathematical properties, as a matter of fact, are ideal, and their precise mathematical meaning could not be realized in the physical universe.

It should be evident by now that there are many interesting problems involved in any consideration of the relationship of mathematics to the sciences. In truth, as a field of study, science and philosophy have only touched the fringe. Real progress in analyzing the many difficulties involved demands more investigators with greater versatility of interest and preparation. Mathematicians need to become more familiar with the sciences, and many scientists must appreciate that a knowledge of mathematics consists of more than a mere ability to manipulate a few mathematical symbols. In the meantime, humanity awaits the many fine accomplishments which will result from a greater mutual understanding between mathematicians and the scientists.

FORTIFICATION OF FOODSTUFFS[1]

By Professor J. MURRAY LUCK
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IT is doubtful whether a single nutrition conference, out of the many that have been held in the past year, has not given some attention to the fortification of foodstuffs with vitamins and minerals. The interest of the public and of the food manufacturer in the problem is evidenced by the increasing number of

[7] G. A. Bliss, *Am. Math. Monthly*, v. 40, p. 472, 1933.
[1] Nutrition Conference: University of California, Berkeley, California, May 3, 1941.

vitamin-enriched foods in grocery stores and the endless array of vitamin products on the shelves of every drug store.

The arguments in favor of vitamin fortification are essentially these:

(*a*) The American housewife on her usual diet of about 2,000 kilocals. per day is unable, despite much ingenuity in the selection of foodstuffs, to satisfy her requirements for the various vitamins as computed from the generally accepted standards.

(*b*) Any given foodstuff, such as milk, for example, varies greatly from day to day, season to season, or place to place, in its vitamin content; incidentally, food tables that purport to give the vitamin values for various foodstuffs are notoriously inaccurate and misleading and have to be used with the greatest of caution.

(*c*) The incidence of malnutrition, especially of subclinical vitamin-deficiency disease, is high. In some cases malnutrition is endemic. Usually those in the low-income groups are the greatest sufferers but in many cases even the well-to-do are afflicted because of bad dietary habits.

(*d*) The use of highly processed refined foodstuffs, as instanced by white flour, C. P. sucrose and margarine, deprives us of valuable food factors present in crude or raw products. Additional losses of considerable magnitude may arise through faulty kitchen technique.

Of the several arguments that have been advanced against the fortification of foodstuffs there are only three or four that need to be regarded as serious:

(*a*) Fortification with pure vitamins is necessarily expensive, even though we make due allowance for the increasing economies that are being effected in quantity production.

(*b*) The removal of vitamins during the processing of foods and their subsequent restoration to the same or even to other foodstuffs is a practice repugnant to one's feeling for the fitness of things: it does not make sense.

(*c*) Enrichment with pure vitamins fails to give recognition to the fact that there are almost certainly additional accessory food factors, as yet undiscovered; the inference is that, were it feasible from the standpoint of food technology, fortification with crude concentrates would be better than with pure vitamins. This argument rests upon the very plausible assumption that 50 mg of pure ascorbic acid are not the equivalent, nutritionally, of 50 mg of ascorbic acid in the form of citrus juices and that 4,000 units of pure vitamin A or carotene are not equal to the crude products or original foodstuffs from which the carotene or vitamin was derived.

It is conceded by many that the problem would be partly solved if we would reconcile ourselves to the consumption of whole-wheat bread instead of ordinary white bread, for B-complex deficiency is one of the common characteristics of low-cost and low-calorie dietaries. At the same time it is perfectly clear that many of us are so stubbornly constituted that we can be reminded day after day of the virtues of whole-wheat bread without paying any heed to such salutary advice. The difficulty is twofold: our dietary habits are very deeply ingrained, and real whole-wheat bread is more expensive than white bread.

I wish to propose that the problem, in so far as bread is concerned, be attacked by establishment of a price differential in favor of whole-wheat bread. This obviously calls for a direct government subsidy, but it follows that the federal government could seek reimbursement through the taxation of white bread. If the millers and bakers can provide us with whole-wheat bread we are quite justified in transferring white bread to the category of taxable luxury goods.

But a very pertinent question is whether such a scheme would work. Would the consumption of whole-wheat bread be increased? Orr and Lubbock[2] have pointed out that in England the price of a banana was 2d in 1900. By 1937 the price had fallen to 1d and the annual consumption of bananas increased from 2½ million bunches to 20 million bunches. Between 1923 and 1935 the price of grapefruit fell 50 per cent. and the annual consumption increased from 1,200 tons to 59,500 tons. These increases were due to a combination of propaganda and fall in price. In the case of whole-wheat bread we now have the propaganda but not the favorable price. It may be contended without any reservations that the creation of a sufficient price differential in favor of whole-wheat bread would increase its consumption, but determination of the "sufficient" differential is entirely a matter of trial. This program has two real merits: it is capable of immediate execution, and it is conducive to the well-being of the low-income groups who are now the greatest sufferers from malnutrition.

Pure vitamins and even vitamin concentrates might well be conserved for therapeutic purposes where a clinical syndrome of vitamin deficiency is in evidence. Wheat germ, dry yeast, rich sources of ascorbic acid, fish liver oils, etc., are to be recommended in the treatment of subclinical deficiencies, and in virtually all cases where the circumstances are appropriate for deliberate enrichment of dietaries—the feeding of the armed forces, of workers in the defense industries, of civilians exposed to special hazards and strain (residents of communities subject to bombing) and of children in schools. In the last-mentioned instance it

[2] "Feeding the People in War Time," Sir John Orr and David Lubbock (Macmillan, 1940).

is hoped that the existing school lunch program will be so extended as to see to it that every child, regardless of economic status, will receive in the schools one thoroughly good meal every day. Apart from the immediate effects of this program, as reflected in the improved health of our children, there is one long term result of immeasurable value—the formation of sound dietary habits.

Let us be well aware of the fact that for children and adults alike education and propaganda are alone insufficient to effect any appreciable improvement in nutritional practices in measurable time. There is much that must be done that can and should be done speedily.

There is reason to believe that the flour-enrichment program of Great Britain has not progressed far, if at all. In any event, it would be unfortunate if the program failed to develop beyond that for which legislative provision has thus far been made. To supplement the present scheme of fortification it is desirable that the consumption of whole-wheat flour and bread be encouraged by reduction of price through a government subsidy. Of necessity the milling of the grain would have to be done in Great Britain because of the failure of whole-wheat flour to keep well when stored. However, the 12 per cent. of residue from fully extracted wheat is a valuable foodstuff for domestic animals and could be put to a profitable use.

SCIENTIFIC EVENTS

THE OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT

THE President of the United States issued on June 30 an executive order establishing the Office of Scientific Research and Development in the Executive Office of the President and defining its functions and duties. Dr. Vannevar Bush, president of the Massachusetts Institute of Technology, now chairman of the National Defense Research Committee, has been appointed director. The first part of the President's order reads as follows:

By virtue of the authority vested in me by the Constitution and the statutes of the United States, and in order to define further functions and duties of the Office for Emergency Management with respect to the unlimited national emergency as declared by the President on May 27, 1941, for the purpose of assuring adequate provision for research on scientific and medical problems relating to the national defense, it is hereby ordered:

1. There shall be within the Office for Emergency Management of the Executive Office of the President the Office of Scientific Research and Development, at the head of which shall be a director appointed by the President. The director shall discharge and perform his responsibilities and duties under the direction and supervision of the President. The director shall receive compensation at such rate as the President shall determine and, in addition, shall be entitled to actual and necessary transportation, subsistence and other expenses incidental to the performance of his duties.

2. Subject to such policies, regulations and directions as the President may from time to time prescribe, and with such advice and assistance as may be necessary from the other departments and agencies of the Federal Government, the Office of Scientific Research and Development shall:

a. Advise the President with regard to the status of scientific and medical research relating to the national defense and the measures necessary to assure continued and increasing progress in this field.

b. Serve as the center for the mobilization of the scientific personnel and resources of the Nation in order to assure maximum utilization of such personnel and resources in developing and applying the results of scientific research to defense purposes.

c. Coordinate, aid, and, where desirable, supplement the experimental and other scientific and medical research activities relating to national defense carried on by the Departments of War and Navy and other departments and agencies of the Federal Government.

d. Develop broad and coordinated plans for the conduct of scientific research in the defense program, in collaboration with representatives of the War and Navy Departments; review existing scientific research programs formulated by the Departments of War and Navy and other agencies of the Government, and advise them with respect to the relationship of their proposed activities to the total research program.

e. Initiate and support scientific research on the mechanisms and devices of warfare with the objective of creating, developing and improving instrumentalities, methods and materials required for national defense.

f. Initiate and support scientific research on medical problems affecting the national defense.

g. Initiate and support such scientific and medical research as may be requested by the government of any country whose defense the President deems vital to the defense of the United States under the terms of the Act of March 11, 1941, entitled "An Act to Promote the Defense of the United States"; and serve as the central liaison office for the conduct of such scientific and medical research for such countries.

h. Perform such other duties relating to scientific and medical research and development as the President may from time to time assign or delegate to it.

THE ASSOCIATED HOSPITAL SERVICE OF NEW YORK

ACCORDING to an announcement made by Dr. S. S. Goldwater, president of Associated Hospital Service of New York, the hospitals and the medical profession of Greater New York and of twelve adjacent counties have been invited to participate in a new non-profit prepayment plan which will provide hospital ward service and all medical services needed for satisfactory clinical treatment.

Affiliated with the service is Community Medical Care, Inc., a new non-profit medical indemnity corporation which received a permit from the State Department of Insurance on June 4. It is under the presidency of Dr. I. Ogden Woodruff, and will be managed by a board of directors consisting of sixteen physicians and eight laymen. The physicians include six past-presidents of County Medical Societies in Greater New York.

The promulgation of the new plan follows more than a year of careful study on the part of the board of directors of the service with the aid of the medical profession, hospital executives, representatives of labor and industry, insurance actuaries and social workers. It has been approved in principle by a special committee of the Coordinating Council of the five County Medical Societies of Greater New York. Details have been submitted to and approved by the State Insurance Department and by the Department of Social Welfare, as required by law.

As soon as a sufficient number of hospitals and physicians signify their willingness to participate, the plan will be offered to groups of workers in industry, many of whom have been asking for a prepayment plan within their means which offers the combination of hospital service and professional care in illnesses requiring hospital admission.

The new plan differs from and supplements the present 3-cents-a-day plan in important respects. The 3-cents-a-day plan, which now has more than 1,250,000 subscribers in the metropolitan area and which during the past six years has paid out benefits amounting to more than twenty-five million dollars, provides hospital service only, in semi-private accommodations. The three-cents-a-day plan was devised for persons of moderate means, who after thus providing for their hospital expenses through a common fund, undertake individually to pay their physicians. Subscribers to the 3-cents-a-day plan pay a subscription rate of $9.60 per annum on a group payroll deduction basis for individual coverage, or $24 per annum for family coverage. Under the new plan, which is known as the community ward plan, comparable subscription rates for hospital service will be only $6 per annum for individuals, and $13.50 for families. To cover medical fees, which are excluded under the 3-cents-a-day plan, and which are a distinctive feature of the new combined plan, subscribers to the community ward plan will pay to Community Medical Care, Inc., subscription rates identical with those paid to Associated Hospital Service for hospital care. Thus the rates for combined coverage, including hospital service and all necessary medical care during the subscriber's hospital stay as provided for in the contract, will be $12 per annum for individuals, and $27 per annum for families, regardless of the number of dependent children under eighteen years of age.

Because of the reduced or "community" rates which participating hospitals are expected to offer under the community ward plan, subscribers to the plan will be limited to single persons with incomes of $1,200 or less; subscriptions providing maternity care as well as general medical and surgical service will be available to husbands and wives with combined incomes of $1,680, and to families including children with incomes of $2,100 or less. Under the new low-cost plan, hospital service and medical care will not be offered separately but only under a combined contract. Administrative costs will be kept at a minimum. Expenses will be shared equally by the two organizations.

According to Dr. Goldwater, the community ward plan involves no necessary change in existing relations between patient and physician, or between physician and hospital. Subject to hospital rules, subscribers will have free choice among participating hospitals.

The Associated Hospital Service offers its new low-cost plan at the conclusion of its sixth year of successful operation, and at a time when it is in a stronger position than ever before. On May 31 the organization reported to the State Insurance Department total admitted assets of $6,166,753 and a surplus of $2,472,247, in addition to a special reserve fund of $1,000,000 for epidemics and other contingencies.

THE SCHOOL OF NUTRITION OF CORNELL UNIVERSITY

THE establishment of a School of Nutrition at Cornell University, offering a two-year curriculum for students who have completed three years of preparatory work at the college level, has been announced by President Edmund Ezra Day. Within the scope of the new unit will be all phases of animal and human nutrition. The new school will cut across college lines and will bring to bear on problems of nutrition facilities now distributed in various departments of five colleges of the university, and in the U. S. Nutrition Laboratory, recently established at Cornell.

According to Dr. Day, "the recent National Nutrition Conference at Washington brought out the fact

that not only is there need for training additional specialists in the science of nutrition and its practical applications, but also for consultation services for professional workers concerned with problems involving nutrition. The School of Nutrition at Cornell will provide such consultation services, as well as scientific training for nutrition specialists."

Dr. Leonard A. Maynard, who has been professor of animal nutrition at Cornell University for more than twenty years and who is director of the Federal Laboratory of Nutrition at Ithaca, has been appointed director of the new unit.

In addition to training specialists in the field of nutrition, instruction will be offered in related fields, where some understanding of the problems of nutrition is essential. Agricultural agents, students preparing for institutional management and chemical engineers and others in training to serve the food industries will be given instruction in various phases of handling and utilizing foodstuffs. Courses will be given for conservationists, veterinarians, physiologists, toxicologists and workers in other divisions of animal sciences.

Students who plan to enter the field will take a course covering five years of college training, at the end of which they will receive the degree of master of science in nutrition. During the first three years the curriculum will include required courses in biology, chemistry, physics, mathematics and animal husbandry. There will follow two years of intensive training in the school of nutrition proper, with special emphasis on animal and human nutrition, bacteriology, general pathology, biochemistry, biophysics and food chemistry. Problems of food supply and food distribution will likewise be studied. Graduates of the school who demonstrate unusual competence will have opportunity to continue their work in a program leading to the degree of doctor of philosophy.

Members of the staff of the new school will be drawn from those divisions of the university most directly concerned with nutrition problems. Among them will be Dr. J. B. Sumner, professor of biochemistry; Dr. P. F. Sharp, professor of dairy industry; Dr. L. C. Norris, professor of poultry nutrition; Dr. F. B. Morrison, professor of animal husbandry; Dr. H. H. Dukes, professor of veterinary physiology; Dr. Hazel Hauck, professor of home economics; and Dr. Clive M. McCay, professor of animal nutrition, who has long been associated with Dr. Maynard in studies on the relationship between diet and longevity. Also associated with the work will be Dr. Eugene F. DuBois, professor of physiology at the Cornell Medical College, and other members of the staff at the Medical Center in New York City. In certain of its aspects, the program of the school will be closely affiliated with the School of Chemical Engineering, which is directed by Dr. F. H. Rhodes, who was recently appointed to the Herbert Fisk Johnson professorship of industrial engineering.

THE McDONALD OBSERVATORY

AN agreement has been made by which Indiana University will join with the University of Texas and the University of Chicago in the use of the McDonald Observatory on Mt. Locke in the Davis Mountains of southwestern Texas. Under the terms of the new agreement it has been arranged that Indiana astronomers will use the facilities of the McDonald Observatory for fifteen nights each year. Indiana University will be given full right to the photographic plates of their observations and also the rights of discussion and publication of the results of their investigations.

The McDonald Observatory was made possible through an $800,000 bequest to the University of Texas by the late William J. McDonald, banker of Paris, Tex., and since its opening it has been manned largely by personnel from the Yerkes Observatory under Dr. Otto Struve. The 82-inch mirror is exceeded only by the 100-inch reflector of Mt. Wilson, Calif. Both mirrors will be surpassed at some future date by the 200-inch telescope of the California Institute of Technology, which is now under construction.

The power of the McDonald Telescope is such that it will take photographs of stars of the order of four hundred million light years distant, and a million times fainter than the faintest star which can be seen by the naked eye. The observatory is situated where climatic conditions are favorable for observations more than three hundred nights a year. The work in astrophysics, which has been carried on at the Yerkes Observatory, has been continued at the McDonald Observatory. Indiana astronomers, under the direction of Professor Frank K. Edmondson, will use the observatory for the study of stellar motions.

THE AFFILIATION OF RUSH MEDICAL COLLEGE WITH THE UNIVERSITY OF ILLINOIS

AN agreement has been entered into for Rush Medical College and Clinic, Chicago, to turn over their facilities to the Presbyterian Hospital, and it in turn to become affiliated with the University of Illinois. The Presbyterian Hospital is close to the Chicago campus of the University of Illinois in the West Side Medical Center.

The affiliation adds members of the faculty, the training and research facilities of one of the city's largest and best-equipped general hospitals and a leading dispensary to the Colleges of Medicine, Dentistry and Pharmacy of the university and the research and educational hospitals and institutes. The latter were transferred, by agreement between the Department of Public Welfare and the university, on

July 1. With the taking over of the state research groups and the affiliation with the Presbyterian Hospital and Rush Medical College there is created a leading medical center.

The name of the college will be perpetuated, as members of its staff who have formed the faculty of the College of Medicine of the University of Illinois will be designated "Rush professors." Members of the Presbyterian Hospital staff will be appointed to the clinical staff of the College of Medicine of the university. Future appointments to the hospital staff will be made from nominations made by the university.

The classes given at Rush Medical College will continue for another two years until students already enrolled complete their work. No new students will be enrolled this fall; newcomers will be eligible to apply for admission to the University of Illinois College of Medicine. The property of the college, hospital and dispensary will remain in the names and under the control of each of those organizations for the carrying out of trusts and other agreements.

For the past seventeen years, Rush Medical College, with the hospital and dispensary, have been affiliated with the University of Chicago, which conducts its own medical college. The authorities at the University of Chicago decided either to join the two medical units or to sever the connection. The trustees of Rush Medical College, however, were not willing to accept such an arrangement, and decided to become affiliated with the University of Illinois.

Under the agreement, the University of Illinois will "formulate a comprehensive coordinated program of undergraduate and graduate medical education and research which shall be designed to use jointly the facilities of the Presbyterian Hospital, the Colleges of Medicine, Dentistry and Pharmacy, and the research and educational hospitals and the institutes of the university." Also, the university will "suggest a program of affiliation for the School of Nursing of the hospital."

The University of Illinois group is the second largest in the west side medical center. It is exceeded only Cook County Hospital, which includes eleven buildings forming the largest general hospital in the world.

THE CHICAGO MEETINGS OF MATHEMATICIANS

THE forty-seventh summer meeting and twenty-third Colloquium of the American Mathematical Society will be held at the University of Chicago from September 2 to 6, in conjunction with meetings of the Mathematical Association of America and the Institute of Mathematical Statistics. The Econometric Society also meets in Chicago. At the time of the meetings the University of Chicago will be celebrating the fiftieth anniversary of its founding, the theme of which will be "New Frontiers in Education and Research."

The Colloquium Lectures will be given by Professor Oystein Ore, of Yale University, under the title "Mathematical Relations and Structures." The Josiah Willard Gibbs Lecture will be given by Professor Sewall Wright, of the department of zoology of the University of Chicago. The title of this lecture is "Statistical Genetics and Evolution." In addition to the usual program of short papers there has been arranged a conference on algebra, a conference on the theory of integration and four general lectures designed for the mathematical group as a whole rather than primarily for specialists in the fields of the lectures. These lectures will have the composite title "Trends in Research," and will describe recent progress and suggest directions which future research in the fields may take. They are as follows: "Abstract Spaces," by Professor M. H. Stone, of Harvard University; "Analytic Number Theory," by Professor H. A. Rademacher, of the University of Pennsylvania; "The Calculus of Variations," by Professor G. A. Bliss, of the University of Chicago, and "Topology," by Professor Solomon Lefschetz, of Princeton University.

The twenty-fourth summer meeting of the Mathematical Association of America will be held from September 1 to 4. In addition to a program of special papers on Monday, a joint session of the society and the association will be held on the afternoon of Wednesday, September 3.

A joint dinner of the societies will be held on Thursday evening at seven o'clock in Hutchinson Commons, preceded by an informal reception at the Raynolds Club.

In connection with the anniversary celebration of the University of Chicago, the American Association for the Advancement of Science will hold meetings during the fourth week of September. Section A will have a session on Wednesday afternoon, September 24, at which Professor Oswald Veblen will give an address on "Spinors and Projective Geometry" and Professor G. D. Birkhoff will speak on "Some Unsolved Problems of Theoretical Dynamics." On Friday, September 26, there will be a symposium on cosmic rays, a joint session of Sections B and D (physics and astronomy), and lectures by Professor E. O. Lawrence on "Nuclear Transformations" and by Professor Henry Norris Russell on "The Cosmical Abundance of the Elements." Complete announcements of these and other scientific sessions held during September will be sent to mathematicians on request to the Director of the Celebration, University of Chicago.

SCIENTIFIC NOTES AND NEWS

DR. JAMES BRYANT CONANT, president of Harvard University, has been appointed chairman of the National Defense Research Committee. He succeeds Dr. Vannevar Bush, who has become director of the newly established Office of Scientific Research and Development.

DR. THOMAS H. NORTON, research chemist of the American Cyanamid Company, celebrated his ninetieth birthday on June 30.

AT the seventieth commencement of the University of Nebraska the degree of doctor of laws was conferred on Dr. Arthur Sperry Pearse, professor of zoology at Duke University.

A WIRELESS dispatch to *The New York Times* states that Dr. Alexis Carrel has been commissioned by Marshal Pétain's Government to organize in France an institute for scientific and medical research. The institute would be in the occupied zone, where Dr. Carrel is at present. Funds for its operation would be granted through subventions by the State.

THE Lamme Medal "for meritorious achievement in engineering" of the Ohio State University has been awarded to Harry C. Mougey, Detroit, technical director of the Research Laboratories Division of the General Motors Corporation.

AT the annual meeting of the Rochester Academy of Medicine the Albert D. Kaiser Medal "for distinguished service to the medical profession" was awarded to Dr. David B. Jewett in recognition of his efforts in building up the library of the academy.

DR. C. H. DESCH, scientific adviser to the British Iron and Steel Research Council, has been awarded the platinum medal for 1941 of the Institute of Metals "for distinguished services to non-ferrous metallurgy." The medal, which is awarded every year, was presented to the institute by the Mond Nickel Company.

SIR THOMAS LEWIS, University College Hospital, London, has been elected a foreign member in the division of medical research of the Royal Swedish Academy of Science.

ACCORDING to the *Journal* of the American Medical Association the annual award of the faculty of medicine of the University of Berne for research on encephalitis will be made retroactively to Dr. B. Disertori, of Trient, Italy, for 1938 and to Professor G. Panegrossi, of Rome, for 1939.

AT the annual meeting of the American Association for the Study of Allergy held in Cleveland on June 2 and 3, Dr. Milton B. Cohen, of Cleveland, was elected president; Dr. Samuel Feinberg, of Chicago, president-elect; Dr. Oscar Swineford, Jr., of Charlottesville, Va., vice-president, and Dr. J. Harvey Black, secretary-treasurer.

DR. L. A. CORWIN, of Jamaica, L. I., was elected president of the New York State Veterinary Medical Society at the Ithaca meeting. He succeeds Dean W. A. Hagan, of Cornell University. Dr. H. H. Fehr, of Buffalo, was elected vice-president and Dr. W. J. Hellman, of Utica, treasurer.

DR. HARDY A. KEMP, professor of bacteriology and preventive medicine and dean of the College of Medicine of the University of Vermont, has been appointed dean of the College of Medicine of the Ohio State University. He succeeds Dr. John H. J. Upham, who has retired.

DR. WILLIAM STOCKTON NELMS, since 1920 professor of physics at Emory University, retired from active service with the title emeritus at the close of the college year.

DR. OLIVER REYNOLDS WULF, of the U. S. Department of Agriculture, has been appointed research associate in physics at the Institute of Meteorology of the University of Chicago. He also will take charge of the Chicago station of the U. S. Weather Bureau.

DR. ROBERT J. TERRY, professor of anatomy of the School of Medicine of Washington University at St. Louis and head of the department, retired in June. He will be succeeded by Dr. Edmund V. Cowdry, professor of cytology.

DR. GEORGE F. KAY, of the University of Iowa, will relinquish his administrative work on September 1. He will become dean emeritus and professor of geology. Since Dr. Kay went to Iowa in 1907 he has served for twenty-three years as head of the department of geology, as state geologist for an equal length of time and as dean of the College of Liberal Arts for twenty-four years.

H. P. GOULD retired on July 1 as head of the Division of Fruit and Vegetable Crops and Diseases of the Bureau of Plant Industry after serving for forty years. He will be succeeded by Dr. John R. Magness, who has been a project leader in the division for several years. Dr. Lee M. Hutchins has been appointed chief of the Division of Forest Pathology. He has been in charge of research on virus diseases of tree fruits, working principally in the South and West. He succeeds the late Dr. Haven Metcalf.

PROFESSOR EARLE D. ROSS, of the department of history of the Iowa State College, has been selected

by the Iowa State Historical Society to prepare a history of agriculture in Iowa for the centennial publication of the society. This book, which Dr. Ross, as research associate of the Historical Society, is preparing this summer, will be one of a series to commemorate Iowa's one-hundredth anniversary of statehood in 1946.

DR. HARRY R. HOFFMAN, associate clinical professor of neurology of the Rush Medical College, Chicago, and director of the Cook County Behavior Clinic, has been appointed state alienist of Illinois, taking the place of the late Dr. H. Douglas Singer. He will be succeeded at the clinic by his assistant, Dr. William H. Haines.

DR. SAMUEL GLASSTONE, research associate in chemistry at Princeton University, has been appointed scientific editor of the Princeton University Press.

DR. ROBERT S. MORISON, of the department of anatomy of the Harvard Medical School, has succeeded Dr. Alexander Forbes as editor of the section of neurophysiology of *Biological Abstracts*. Dr. Ralph G. Smith, of the Medical School of the University of Michigan, has become editor of the section of pharmacology in the place of Dr. Erwin C. Nelson.

DR. SHARAT K. ROY, curator of geology at the Field Museum of Natural History, left Chicago on July 1 for western New York to collect specimens of invertebrate fossils of the Paleozoic era. Dr. Fritz Haas, curator of lower invertebrates, has recently returned to the museum after a two months' expedition to Southern California, where he collected specimens of Pacific shore animals.

DR. MADISON BENTLEY has completed a term as special lecturer in psychology at Goucher College. On June 2 he lectured before the Rochester Psychology Society on "The Hominid Animal from Egg to Age." Since he left the consultantship in psychology at the Library of Congress his address has been Palo Alto, Calif.

DR. GEORGE W. CORNER, director of the department of embryology of the Carnegie Institution of Washington at the Johns Hopkins University, delivered on May 6 the sixth Leo Loeb Lecture before the St. Louis Medical Society. His subject was "The Ovarian Cycle."

DR. CECIL K. DRINKER, professor of physiology and dean of the School of Public Health of Harvard University, will give from October 6 to 20 a series of five Lane Lectures at Stanford University Medical School, on the general subject of the lymphatic system. The Lane Medical Lectures, given biennially, were founded in 1896 by Dr. Levi Cooper Lane.

IT is planned to build a laboratory for medical physics with a staff of five research workers at the University of California at Berkeley. This has been made possible by a gift of $165,000 from an anonymous donor to build and equip the laboratory; and a contribution of $50,000 from the Columbia Foundation of San Francisco for the payment of salaries. The laboratory will represent a union of physics and medicine and other branches of science, such as chemistry, bacteriology, biology and genetics. The plans are under the direction of Dr. John H. Lawrence, who now is in charge of medical investigations with the cyclotron.

BY the will of Dr. Robert S. Forsythe, formerly head of the department of book selection at Newberry Library, Chicago, the sum of $100,000 for research on asthma is bequeathed to Harvard University.

J. P. ANDERSON, of Juneau, Alaska, has given to Iowa State College one of the largest collections of Alaskan plants in the United States. It comprises more than 10,000 specimens. Mr. Anderson, a graduate of Iowa State College of the year 1914, has been active in Alaskan public affairs, recently serving in the territorial legislature and as superintendent of census. He plans to increase the selection further this summer and to carry on research with Alaskan plants at Iowa State College next fall.

THE Institute of Medicine of Chicago announces the establishment of a foundation to be known as the Edwin R. Kretschmer Memorial Fund, given by Dr. Herman L. Kretschmer, the Chicago surgeon, and Mrs. Kretschmer, in memory of their son, who died last February. Income from the fund is to be used for lectures on myelogenic leukemia and for research in the field of blood dyscrasia. Dr. Kretschmer is a member of the Board of Governors of the Institute of Medicine and treasurer of the American Medical Association.

REVISED examinations have been announced by the Civil Service Commission for those qualified in all branches of naval architecture and marine engineering. They are particularly needed for positions in the assistant and associate grades ($2,600 and $3,200 a year, respectively). However, naval architects or marine engineers qualified to fill all the grades (salaries range as high as $5,600 a year) are urged to apply at once, although applications will be accepted until June 30, 1942. The commission will not accept applications from those who successfully passed the examinations for the position of naval architect or marine engineer which closed on June 30, unless they are now eligible for rating in a higher grade. Those who have been placed on the commission's em-

ployment list will be retained on the new list to be established as a result of the examinations just announced. An open continuous examination for inspectors of naval ordnance materials is also announced. No written examinations are being given, but applicants are being rated on the basis of education, training and experience as shown on the applications. Any one under 65 years of age qualified in any of the several fields connected with the work is eligible for positions, which carry salaries ranging from $1,620 to $2,600 a year for the various grades. To qualify for either of two higher grades, considerable experience must be shown in one of the four specific branches of naval ordnance: optical and fire control instruments, naval guns and accessories, munitions or ordnance units. In the lower grades an applicant may qualify on education alone or by showing the proper amount of experience in varied fields.

FIVE members of the faculty of the University of Chicago have been appointed by President Robert Maynard Hutchins as a Committee on Biology and Medicine to further the publication through the University Press of books in the field of medicine and the biological sciences. Members of the committee are: Dr. William H. Taliaferro, dean of the Division of the Biological Sciences, chairman of the department of bacteriology and parasitology; Dr. Franklin C. McLean, professor of pathological physiology; Dr. C. Phillip Miller, associate professor of medicine; Thomas Park, assistant professor of zoology, and Dr. Lester R. Dragstedt, professor of surgery. The committee will advise the University of Chicago Press of research suitable for publication, will plan needed texts, and act as a possible outlet for valuable work now being done throughout the country in the biological and medical fields. In the matter of securing manuscripts, the committee will be assisted by an advisory group, one man from each department of the biological sciences at the University of Chicago.

THE American Standards Association has announced the publication of a new list of American Standards for 1941. It is pointed out that in view of the importance of standards and specifications not only for every-day work but to speed up production to meet defense requirements, this particular list of standards will be of unusual interest to industry. More than four hundred American Standards are listed, covering definitions, technical terms, specifications for metals and other materials, methods of test for the finished product, dimensions, safety provisions for use of machinery and methods of work. They reach into every important engineering field and serve as a basis for many municipal, state and federal regulations. Six hundred manufacturing, government and user groups have shared in their development. The list will be sent free of charge to any one interested in the work. Requests should be addressed to the American Standards Association, 29 West Thirty-ninth Street, New York, N. Y.

DISCUSSION

EVIDENCE OF UNDERTOW FROM ENGINEERING PRACTICE

DOUBTS as to the existence of the undertow were raised some years ago by Professor W. M. Davis.[1] Some years later Shepard[2] described river-like movements of water that here and there flow outward nearly perpendicular to the shoreline, and supported Davis in his suggestion that the undertow is non-existent.

The presence of outward moving surface currents does not, of itself, disprove the existence of undertow, since it is conceivable that water forced on a lee shore by the wind might escape in either or both ways. Investigations by Evans[3] have proved the existence in lakes and ponds of fairly strong subsurface currents which move outward from shore during on-shore winds and are reversed in direction during off-shore winds. This suggests that similar movements may take place in larger bodies of water but does not prove it.

It is evident that both Davis and Shepard in their discussions have used the word "undertow" in the popular sense of strong subsurface currents moving outward in the comparatively shallow water near shore and have left out of consideration those subsurface movements that occur farther off-shore and which Davis[4] mentioned but seemed to dismiss as of little importance. As originally used, the word "undertow" was intended to apply to subsurface currents extending entirely to the outer edge of the subaqueous terrace and even beyond. Russell says:[5]

> The finest of the waste from the land is carried lakeward by the undertow and finally deposited as lacustral beds; portions less finely comminuted fall on the outer slopes of the terrace and serve to broaden it.

Also Gilbert[6] uses the term in the same way when he says:

> The finer portion (of the detritus) being lifted up by

[1] SCIENCE, 61: 206–208, 1925.
[2] SCIENCE, 84: 181–182, 1936.
[3] SCIENCE, 88: 279–281, 1938.
[4] *Op. cit.*, 207, 1925.
[5] I. C. Russell, "Geological History of Lake Lahontan," pp. 88–89, U.S.G.S., Mono. 11, 1885.
[6] G. K. Gilbert, "Lake Bonneville," p. 33, U.S.G.S., Mono. 1, 1890.

the agitation of the waves, is held in suspension until carried outward to deep water by the undertow.

Several studies relating to problems of water supply and sewerage disposal have been made by engineers in the Great Lakes region for the purpose of determining the movement of sewerage, the spread of turbidity and the bacterial count. In discussing such studies Townsend[7] says:

> With the wind blowing from the shore, this sewerage flows on the water surface and the pure lake waters flow along the lake bed. When the direction of the wind is reversed, the sewerage flows along the bed and pure water on the surface. The intake gates to the water supply tunnels can be manipulated accordingly.

Burdick,[8] in discussing the conditions at Chicago and Gary, states that with on-shore winds the travel of the surface water is shoreward, that there is an undertow outward, and that the turbidity developed in the shallow water is carried out to the deeper water in this way. He says this turbidity is noticeable at the water intake at Gary with a north (on-shore) wind and that with a south (off-shore) wind the bacterial count is least.

Investigations of methods of protecting the water supply of Milwaukee gave further evidence of subsurface currents.[9] It was found that with an on-shore wind there is an undertow, and that with an off-shore wind there is a subsurface current in the other direction. This wind-induced circulation reached a depth of 65 feet. A somewhat similar study by Whipple[10] regarding sewerage disposal in Lake Erie indicated similar current conditions there. With an on-shore wind the sewage moved off-shore on the lake bottom and with an off-shore wind it moved off-shore at the surface while on the bottom it moved somewhat inshore.

In describing current studies at Squam Lake, New Hampshire, Whipple[11] states:

> Floats near the surface drifted with the wind, while the deeper floats moved in the opposite direction. It was found that the greater part of the return circulation was above the transition zone, but that even below the transition zone there was some movement of the water. . . . In summer, when the lake is vertically stratified, these currents remain largely confined to the circulation zone.

According to the studies cited above, wind-induced currents are common and are confined, in summer, mostly to that part of the water body above the thermocline. On the Great Lakes this is from about 50 to 100 feet below the surface. On Squam Lake, at the time the studies were made, the lower part of the thermocline was at a depth of about 48 feet. According to Whipple's diagram, the surface current extended down to a depth of about one third of the distance from the water surface to the bottom of the thermocline, and Metcalf and Eddy's diagrams showing conditions at Milwaukee and at Rochester suggest about the same relation.

On the east shore of Lake Michigan the bottom slope is so gradual that a depth of 15 to 20 feet is not usually reached until 800 to 1,200 feet from shore. Under these conditions it is probable that a definite surface and subsurface circulation is not present near shore during heavy storms and that where the water has less depth than that to which the surface current penetrates, the water movements are uneven and disorganized and the water driven on-shore by the wind escapes outward in localized currents either on the surface or below. It may even move parallel with the shore for some distance before reaching a place where the shoreline and conditions of bottom topography are favorable for off-shore movement. Thus the "rip currents" described by Shepard are a part of this outward movement, but there is sometimes also a subsurface escape in favorable localities, as was observed by Evans[12] on the east shore of Lake Michigan.

The above observations seem to indicate that if we mean by "undertow" an outward moving subsurface sheet of water beneath the layer that is being driven shoreward by on-shore winds, such a current does not exist closer to shore than where the depth of water is about equal to the thickness of the shoreward drifting sheet but that it does exist in the greater depths offshore. In the zone nearer shore the water movements are localized and may be in any direction and either at the surface or below.

O. F. EVANS

UNIVERSITY OF OKLAHOMA

A BACTERIAL PATHOGEN OF THE CITRUS RED SCALE

ADULT females and crawlers of the red scale on field lemons can be infected and destroyed, under laboratory conditions, by a spore-forming, nitrate-reducing motile bacterium isolated from a certain soil, in connection with denitrification studies. A similar, if not identical, microorganism was later found in the dead red scale in some lemon orchards.

Spraying with active cultures, immersion and dusting with the spores of the bacterium were studied as methods of bringing about a mass infection of the scale on lemons and on a number of other hosts. Mortality

[7] Curtis McD. Townsend, "River and Harbor Construction," p. 83, The Macmillan Company, 1922.

[8] C. B. Burdick, "The Relation of the Intake to Pure Water from the Great Lakes," p. 40, Illinois Water Supply Association Proceedings, 1911.

[9] Metcalf and Eddy, "American Sewerage Practice," pp. 201–204. McGraw-Hill Book Co., Inc., 1935.

[10] *Ibid.*, pp. 197–200.

[11] G. C. Whipple, "The Microscopy of Drinking Water," 4th Edition, pp. 161–162. John Wiley and Sons, Inc., 1927.

[12] O. F. Evans, *Jour. Geol.*, Vol. XLVII, No. 3, 1939.

of the adult females was found to be in the vicinity of 100 per cent. under certain conditions. Immersion and dusting with the bacterial spores fruits previously sprayed with water appeared to offer more promise than spraying alone.

Within a few days after the infection the pygidia of the scale often become distorted. Evolution of gas and a more or less general browning of the insect often occur simultaneously. Vegetative cells of the bacterium, as well as its spores, can be observed in the contents of the general cavity. Saprophytic fungi frequently invade the diseased or dead insect.

A detailed article containing experimental data has been submitted to *Phytopathology*.

V. P. SOKOLOFF
L. J. KLOTZ

UNIVERSITY OF CALIFORNIA

PRO AND CON EVOLUTION IN CONTEMPORARY GERMANY

THE attacks on evolution, discussed under the above heading in SCIENCE, 93: 40, 41, have been also contradicted in two articles of the German monthly *Der Biologe* (year 9, fasc. 12, December, 1940, which was received here in May, 1941).

The first of those articles, by the geneticist, F. Schwanitz (*l.c.*, pp. 407–413), bearing the title "Ein Kreuzzug gegen die Abstammungslehre" ("A Crusade against Evolution"), deals with the "Sonderheft" (4/5, vol. 37, April/May 1940) of "Natur und Kultur," particularly with Otto Muck's essays, which are harshly refuted and stripped of any scientific significance.

The second article, entitled "Immer wieder: Abstammung oder Schöpfung?" ("Again and again: Evolution or Creation?"), by Chr. von Krogh (*l.c.*, pp. 414–417), who recently[1] participated in the German scientific discussion on "Menschwerdung" (origin of man), deals chiefly with an anti-evolutionary pamphlet of H. Frieling,[2] one of the contributors to the aforementioned special publication. Von Krogh rejects it for both scientific and philosophical reasons, claiming that Nordic man always believed in unity of body and soul, whereas dualism is assigned to Eastern conception of life.

OTTO HAAS

THE AMERICAN MUSEUM
OF NATURAL HISTORY

CARL FRIEDRICH GAUSS'S DESCENDANTS IN AMERICA

GAUSS, who is probably one of the four greatest mathematicians who ever lived, was twice married. By his first wife he had two sons (Joseph, 1806–73, and Louis), and by his second also two sons (Eugene, 1811–96, and Wilhelm, 1813–79). Louis died in childhood. Joseph was an engineer, and in 1836 and 1837 he was sent by his government to the United States to study railway construction in the New World. Eugene came to the United States in 1831 and enlisted as a private in the U. S. Army for five years. In 1840 he settled in St. Charles, Mo., married, and had a family of seven children. His younger brother Wilhelm came to this country in 1837, immediately after his marriage to a niece on his mother's side of the astronomer Bessel. For about a score of years he was engaged in farming in Missouri. Thereafter he entered the wholesale shoe business in St. Louis, in which he continued until his death. Of his eight children six were living in 1899. In January, 1935, one of these children, Joseph H. Gauss, was still living, and dean of the Brookes Bible Institute of St. Louis. Other descendants are in Colorado and California. Most of the information given above, and much more, may be found in *C. F. Gauss und die Seinen. Festschrift zu seinem 150. Geburtstage,* herausgegeben von H. Mack, Braunschweig, 1927, and in two articles by Professor Cajori: (a) "Carl Friedrich Gauss and His Children," SCIENCE, n.s., v. 9, 1899, pp. 697–704; and (b) "Gauss and His American Descendants," *Popular Science Monthly,* v. 81, 1912, pp. 105–114.

This supplies information requested by a correspondent, Sir Joseph Larmor, in your issue for May 30, page 523.

R. C. ARCHIBALD

BROWN UNIVERSITY

SCIENTIFIC BOOKS

MATHEMATICS

Gap and Density Theorems. By NORMAN LEVINSON. American Mathematical Society Colloquium Publications. Vol. 26. New York, 1940. viii + 244 pages. $4.00.

ONE of the fundamental properties of the system of trigonometric functions (cos nx, sin nx), or of the equivalent system of exponential functions (e^{inx}), is the property of closure. It is precisely this property that makes them so important in problems of expansions of arbitrary functions in Fourier series. The natural question under what conditions this property is enjoyed by a more general system of functions ($e^{i\lambda_n x}$), has interested several earlier writers, among whom the name of G. D. Birkhoff should be mentioned. Several important problems in this direction were

[1] *Zeitschr. ges. Naturw.*, pp. 105–112, 1940.
[2] "Herkunft und Weg des Menschen. Abstammung oder Schöpfung?" Klett, Stuttgart, 1940 (113 pp.).

stated and solved by G. Pólya. A new impetus to the problem was given by the work of Paley and Wiener. The first part of the present book (Chapters I–IV) continues the work of Paley and Wiener, and extends it to a final form, in a certain sense. The method of Paley and Wiener, based on the consideration of Fourier Transforms in the complex domain, is successfully used by the author in treating various other problems of the theory of functions of complex variables. Such are problems connected with vanishing of Fourier Transforms, distribution of zeros and singularities of analytic functions, and the rate of growth of analytic functions (Chapters V–VII). In Chapters VIII and IX the author extends the work of Pólya concerning entire functions of zero order and shows that his results are in a certain sense the best possible. Finally in the last part of the book (Chapters X–XII) the author gives a considerable extension of a remarkable theorem of Hardy and Littlewood, where the convergence of a series is derived from its summability by a certain method, without any additional conditions on the terms of the series. Due to its technical character, the reading of the book is not very easy; however, the exposition is very clear and precise, and the reader who will stick to his job will feel greatly rewarded at the end.

Fourier Series and Boundary Value Problems. By RUEL V. CHURCHILL. ix + 206 pages. New York: McGraw-Hill Book Company. 1941. $2.50.

THE literature in English on the subject of partial differential equations of mathematical physics is rather restricted. Expositions of introductory but not entirely formal nature are practically non-existent, and the present book represents a welcome contribution in this direction. In the first two chapters the author discusses the notion of a boundary value problem for linear differential equations and derives some simplest differential equations of mathematical physics. In the next three chapters the author introduces the notion of orthogonal sets of functions, discusses properties of being closed and complete, and applies the general principles to the special case of trigonometric Fourier series. Simple fundamental facts concerning convergence of Fourier series and operations with Fourier series are discussed here, and the notion of Fourier integral is introduced. Chapters VI and VII give applications to solution of simplest boundary value problems of the theory of heat conduction and potential theory. Much attention is given to the question of uniqueness of solutions. Finally, in chapters VIII and IX the author introduces Bessel functions and Legendre polynomials and considers some applications to boundary value problems. Exposition is clear and "rigorous" as far as possible in a book of elementary character. The notion of Laplace transform is omitted although it seems quite desirable and worth mentioning. The author promises, however, another volume of a more advanced nature where further methods of solving boundary value problems will be treated.

J. D. TAMARKIN

BROWN UNIVERSITY

SOCIETIES AND MEETINGS

THE KANSAS ACADEMY OF SCIENCE

THE seventy-third annual meeting of the Kansas Academy of Science was held at Manhattan, Kansas, on April 3, 4 and 5, 1941, with Dean E. O. Deere, Bethany College, Lindsborg, Kansas, presiding. The Kansas Entomological Society, which is affiliated with the academy, held its seventeenth annual meeting on April 5. The following other state societies held their meetings in cooperation with the academy: The Kansas Association of Teachers of Mathematics, the Kansas chapter of the Mathematical Association of America, and the Kansas chapter of the American Association of University Professors. The Weather Crops Seminar, another affiliated society, held its meeting last November.

The academy program opened with a Thursday evening lecture under the joint auspices of the Kansas State College chapter of Gamma Sigma Delta and the academy by President W. M. Jardine, of the University of Wichita, who spoke on "Egyptian Agriculture."

After sectional meetings on Friday morning for Botany, Zoology, Psychology and Geology from 9 to 11 A.M., a general academy business meeting was held. Recipients of the six research awards for 1940 reported briefly on the results of their work.

More definite plans were made for the celebration of the seventy-fifth anniversary of the academy in 1943 at the Lawrence meeting. This "Diamond Jubilee Committee" is planning to prepare an extended report on the chief contributions to science by the various institutions of the state during the seventy-five years of academy activity.

Sectional meetings for Botany, Chemistry, Physics, Psychology, Zoology and a Geological field trip were held on Friday afternoon.

At the annual banquet on Friday evening, Dr. S. A. Nock, vice-president of Kansas State College of Agriculture and Applied Science, spoke appropriate words of greeting and gave a challenge of the times to science and scientists. Dr. J. T. Willard spoke on per-

sonal "Reminiscences" of some of the founders and earlier members of the academy.

The banquet was followed by the annual public meeting, which this year was a joint symposium sponsored by the Mathematical Societies and the academy. Dr. L. C. Heckert, head of the department of physical science at Kansas State Teachers College at Pittsburg, spoke on "Kansas Resources and National Preparedness." Dr. William L. Hart, professor of mathematics at the University of Minnesota, representing the Mathematical Societies, spoke on "Mathematics and National Preparedness."

The next business meeting was held on Saturday morning. President Deere gave his presidential address on "Crowding and its Effect on Organisms." Dr. J. R. Wells reported the decisions of the judges and the names of the winners of the awards of the junior academy meeting. Robert Beck of Manhattan, and Frances Chubb of Lawrence, were nominated for the honorary junior memberships in the A.A.A.S. for the coming year.

Mrs. Otilla Reagan, donor of the Albert B. Reagan memorial fund, attended the meeting and spoke briefly of some pamphlets on the life and work of Dr. Reagan which she has for distribution.

insects at various altitudes by airplane; a $40.00 Kansas Academy of Science award to Lawrence Oncley and William B. Plum, both of Southwestern College, for research on the vitamin content of the beans of the Kentucky coffee tree. It was decided that, beginning with the awards for 1941, the recipients will not be given their awards in cash but that a credit be established to the amount of each award and that statements or bills be presented by the recipients for apparatus, labor, travel expense or other expense in carrying on the research projects.

Dr. Roy Rankin reported on the death of Dr. W. R. B. Robertson, the only known death in the academy ranks during the year. Dr. W. H. Mikesell, of the University of Wichita, chairman of the committee on educational trends, gave the report of an extended study of the psychology course as given in the high schools of the state.

Total academy registration was 488. In addition, the junior academy had a registration of approximately 200; the Kansas Entomological Society 55; the Mathematical Societies 135; the University Professors 45.

The reports from the section chairmen on their sections is presented herewith in tabular form.

SECTION RECORD, WITH PAST AND FUTURE OFFICERS, MANHATTAN MEETING

Name of section	Chairman of section for the meeting	No. papers on program	No. persons attending	Chairman for 1942
Biology Teachers	H. H. Hall	7	43	R. L. Tweedy
Botany	F. W. Albertson	26	60	Stuart Pady
Chemistry	K. S. Bergstresser	12	90	Leonard C. Kreider
College Students	M. W. Allen	14	120	M. W. Allen
Entomology	R. L. Parker	23	55	Don B. Whelan
Geology	Carl Barnhart	22	55	Geo. M. Robertson
Junior Academy	Don Marchbanks	{ Class A Schools }	200	John Michner
Committee Chairman	J. R. Wells	{ Class B Schools }		L. D. Wooster
Physics	S. Winston Cram	18	60	K. V. Manning
Psychology	Geo. A. Kelly	18	70	H. E. Schrammel
Physical Science	Lawrence Oncley			
Weather Crops	W. A. Cochel	Meeting in November		R. H. Wheeler
Zoology	R. E. Bugbee	38	100	E. H. Herrick
Kans. Assoc. Teachers Mathematics	Mrs. Adelle Davis	5	50	Miss Kathleen O'Donnell
Math. Assoc. of America, Kansas Chapter	G. Baley Price	9	85	C. V. Bertsch
A. A. University Professors	R. W. Conover	7	50	A. B. Sageser

Three new life members, Dr. Edwina A. Cowan, Marion I. Campbell and Dr. J. E. Ackert were added to the roll of life members.

The following research awards for 1941 were announced by P. S. Albright, Southwestern College, chairman of the research committee: The $32.50 Reagan award No. 5 was given to Travis Brooks, Kansas State College, for research on the Myxomycetes of Kansas; a $40.00 American Association for the Advancement of Science award was made to Leslie L. Eisenbrandt, University of Kansas City, whose research work at Kansas State College is a study of the intestinal mucosa for an inhibitory growth factor for nematodes; a $35.00 A.A.A.S. award to Leonard H. Moulden, Kansas State College, for aid in collecting

A sectional program for college students was an innovation this year and proved to be so successful that it was made a permanent feature. The section will be managed by an academy committee to insure continuity.

The next annual meeting of the academy and the same cooperating societies for 1942 will be held at Hays, Kansas; the meeting for 1943 will be held at Lawrence and the invitation from Pittsburg, Kansas, was accepted for 1944.

The following officers were elected for the next year and meeting: *President,* F. C. Gates, Kansas State College; *President-elect,* R. H. Wheeler, University of Kansas; *Vice-president,* H. A. Zinszer, Fort Hays Kansas State College; *Secretary,* John C. Frazier,

Kansas State College; *Treasurer,* F. W. Albertson, Fort Hays Kansas State College.

Executive council members are L. D. Bushnell, Kansas State College, E. O. Deere, of Bethany College, and H. H. Hall, Pittsburg. Two associate editors, chosen for three years, are J. A. Trent, Pittsburg State Teachers College; and W. H. Schoewe, of the University of Kansas. Dr. Robert Taft, of the University of Kansas, is the new editor of the "Transactions." The writer will serve the second year of his three-year appointment as representative to the academy conference at Dallas with President Gates as alternate.

ROGER C. SMITH

MANHATTAN, KANSAS

REPORTS

ADDITIONAL COOPERATIVE STUDIES OF THE RELATION BETWEEN MOSQUITO CONTROL AND WILDLIFE CONSERVATION[1]

A PREVIOUS report of the Technical Committee[2] outlined the mechanism for the conduct of investigations for the coordination of programs of malaria control and wildlife conservation in the impounded waters of the Tennessee Valley Authority. This report briefly outlined the studies conducted during the season of 1939. The work of this committee has continued through the summer of 1940 and it is desired at this time to make a brief progress report.

It is recognized that the production of *Anopheles quadrimaculatus* is closely associated with aquatic vegetation. It is also known that certain species of aquatic plants are objectionable, both because they favor the production of mosquito larvae and because they have no value as food for wildlife. This has led to an intensive investigation of the relative importance of various species of aquatic vegetation in the production of *A. quadrimaculatus.*

Quantitative studies were undertaken to determine the relative importance of individual aquatic species in the production of this mosquito. Twenty species of aquatic plants were studied, but emphasis was placed upon nine of these. Plots five yards square were adopted as the unit of study and usually four or more such plots were sampled for each plant species in a given area. Ten square-foot samples were collected from each plot by means of a screen dipper and strainer pan. All anopheline larvae were classified according to their instars, and species determinations were made of most fourth instar larvae. Estimates were made of the vegetative cover and the amount of flotage in each square-foot sampling station. Altogether, 3,000 individual samples were taken during the summer. The results of these studies indicate that, with the possible exception of watershield (*Brasenia schreberi*), which may inhibit larval production, factors other than the individual species of vegetation are of primary importance in determining the extent of anopheline production in a given area. It was apparent that structure and growth characteristics of the plants and the way they interact with a combination of external factors such as flotage, water-level, wind action, the amount of vegetation edge-line at the water surface, etc., were more significant in anopheline production than were mere species differences. Because of water-level fluctuations for malarial control and variations brought about by floods, navigation, and power uses, the marginal vegetation in the reservoirs of the Tennessee Valley Authority presents problems widely different from those found under more stable conditions. At high-water levels emergent vegetation was important in anopheline production, while at low-water levels submerged species became important. Floating-leaved species were important at both high- and low-water levels. In general, there was a positive correlation between the density of anopheline larvae and the abundance of flotage and frequently with the amount of vegetative cover.

Experimental studies have been conducted on the control of vegetation objectionable to malaria control and wildlife interests. Experimental applications of powdered sodium arsenite were made by airplane at monthly intervals at the rate of approximately eight pounds per acre. With the exception of lotus, the control of the various species obtained by four applications was encouraging. Coppice was particularly susceptible to sodium arsenite. While complete control can not be anticipated at present, it is felt that such applications might reduce the vegetative cover sufficiently to make the application of larvicides more effective and even reduce the need for these. A wide variety of liquid herbicides has been tested on alligator grass (*Achyranthes philoxeroides*), but no definite conclusions have been reached at this time. The utilization of an underwater weed cutter in the control of lotus (*Nelumbo lutea*) and cowlily (*Nymphaea advena*) has given very encouraging results.

Experimental plantings of sixteen species of vegetation important to wildlife have been made in the Wheeler refuge. These plantings indicate that three species suitable for waterfowl, namely, four-angled

[1] Report of the Technical Committee for 1940 by E. Harold Hinman (*chairman*), John Steenis, W. V. King, J. L. Robertson, Jr., A. H. Wiebe, Clarence Tarzwell and A. D. Hess.

[2] E. L. Bishop, SCIENCE, 92: 201–202, 1940.

spike rush (*Eleocharis quadrangulata*), soft-stem bulrush (*Scirpus validus*) and three-angled bulrush (*S. americanus*) are tolerant to fluctuation and draw-down of water-level and might be effectively fitted into existing plant associations at certain contours so that they would not add materially to the malaria control problem.

A large number of soil samples for arsenic determinations were taken from the reservoirs in the spring of 1940 prior to the application of Paris green, and similar series in October at the cessation of larvicidal activities. Analyses of these samples show no significant increase in the amount of arsenic in the soil.

A study was conducted to obtain information on the feeding habits of *Gambusia* with special reference to its predation on *Anopheles* larvae. The forage ratio[3] was adopted as a measure of the feeding preference of *Gambusia* for anopheline larvae and pupae. The forage ratio is obtained by dividing the percentage of a given kind of organism in the fish stomachs by its percentage in the environment. The ratio will vary above and below one accordingly as the predator prefers or avoids the particular prey. The forage ratio may be calculated from number, weight or volume of organisms; in this study numerical forage ratios were used. Enclosing the study plots with a barrier seine made it certain that the fish whose stomachs were examined had fed in the same plot from which the samples of food organisms were collected. About 30 square-foot samples were selected at random from each plot to be investigated, and both the macroscopic and larger microscopic organisms were counted and identified. Immediately after the collection of these organisms, the *Gambusia* were collected from the plot, preserved in formalin, and taken to the laboratory for analysis of stomach contents. Three ecological conditions were studied, and in each of these, study plots were selected which contained the maximum number of larvae. One represented typical problem areas of the reservoir subjected to fluctuation; a second was a protected bay of the main reservoir dammed off so that terrestrial vegetation was flooded and the water-level kept relatively constant; the third type was an area newly impounded during the late summer after terrestrial vegetation was well advanced and when wind action had caused flotage concentration. These studies involved the collection and examination of 295 square-foot samples of surface-dwelling food organisms and the collection and examination of stomach contents of 968 *Gambusia*. The feeding preference for anophelines increased as their absolute density increased, the forage ratio being one when the larval density was about two per square foot; above this density the forage ratio increased, and below this density it decreased. The feeding preference for anophelines increased as the size of the larvae increased; no first instar larvae were found in the stomachs and the forage ratio for fourth instar larvae was greater than for second or third instar larvae. The forage ratio for pupae was greater than for any larval instar. It was concluded that predation of *Anopheles* by *Gambusia* in these areas was sufficient to reduce materially production of adults. However, this reduction is not considered sufficient, under the conditions represented in certain areas, to eliminate the need for other control measures.

Preliminary investigations have been carried on regarding the *Odonata* as predators of anopheline mosquitoes. Dr. Allan F. Archer also conducted certain investigations on the predation of spiders on adult mosquitoes.

Through the cooperation of the Fish and Wildlife Service, the Tennessee Valley Authority and the WPA, provisional plans were made to dyke off an extensive shallow area in the Wheeler Refuge as a means of eliminating a serious anopheline breeding area and at the same time providing a source of winter food for migratory waterfowl. The areas will be dyked off, connected by dragline ditches, and a single pumping structure will be utilized to dewater the area at the onset of mosquito production. The area can then be maintained in a dewatered state throughout the summer, permitting the planting of suitable species of plants for wildlife food. At the close of the mosquito breeding season the area will be flooded to provide feeding grounds for migratory waterfowl. The inclusion of two-way pumps will permit these operations even at times when the lake is at low elevations.

At a joint meeting of the Policy and Technical Committee at Knoxville, December 6, 1940, it was agreed that, since a working relationship now exists whereby a study of these problems may be continued as a part of the regular research programs of the interested agencies, the formal organization should be discontinued. It was stated further that it would be the purpose of the participating agencies to continue at the present or increasing levels the program of cooperative research which has been developed.

[3] A. D. Hess and A. Swartz, *Trans. 5th North Amer. Wildlife Conf.*, pp. 162–164, 1941.

THE CHICAGO MUSEUM OF SCIENCE AND INDUSTRY

LAST fall the Chicago branch of the American Association of Scientific Workers appointed a distinguished committee of its members to look into the problems raised in connection with the dismissal from the Museum of Science and Industry of a number of members of the scientific staff. The accompanying report by this committee has been unanimously approved by the executive committee of the association.

R. W. GERARD,
President, Chicago Branch

REPORT OF THE COMMITTEE

Your committee wishes to report its conclusions in regard to recent dismissals of members of the staff of the Museum of Science and Industry in Chicago. A study has been made of the facts available to us. Our recommendations are given as a part of our findings.

Preamble

a. It seems clear that a change in the general policy of the museum was favored by the trustees, partly in the interest of necesssary saving, and that these changes in policy could be furthered by a change in personnel, such as was actually ordered. Whether such changes in policy are themselves desirable is a point on which your committee, having only a limited acquaintance with the management of the museum, can scarcely pass. Such decisions are properly within the responsibilities of the Board of Trustees of the museum. We have, however, no evidence that the Board of Trustees consulted competent men, outside its own ranks and the museum staff, in reaching a decision.

b. There may have been budgetary savings in the reorganization effected by the discharges; the significance of such savings your committee is not in a position to evaluate.

c. Your committee is pleased to observe that the policy expressed by the president of the museum is to continue emphasis on education rather than on entertainment.

Findings

a. ***The method of dismissal of the Director and the chiefs of departments, without consultation and without due process, is, in our opinion, contrary to justice and to sound practice, especially in a public educational institution.*** According to Mr. Lohr, this procedure of avoiding contact with the men before action was taken and basing his decision primarily upon administrative and budgetary needs, was adopted in an effort to avert implications detrimental to the individuals dismissed. We believe that in a public educational institution, staff members, after proven competence, should have tenure and be subject to removal for cause only after a proven hearing. Moreover, from a financial viewpoint, a minimum of ameliorative measures seems to have been taken to lighten the blow upon those discharged. Such amelioration was scaled upon the standards prevailing in business rather than upon those prevailing among scientists.

b. We trust that the board will provide more adequate restitution to the persons discharged. Such steps would restore to the museum a place of confidence with the citizens of Chicago and the scientific public.

c. It will be helpful to the understanding of the museum's position if its Board of Trustees will make a public statement of its policy.

ANTON J. CARLSON
ARTHUR H. COMPTON
CHAS. H. BEHRE, JR.

SPECIAL ARTICLES

ASSOCIATION OF THE WASSERMANN ANTIGEN WITH HEAVY MATERIALS PRESENT IN TISSUES[1]

THE material present in normal and neoplastic tissues and sedimentable at 27,000 r.p.m. during one hour has been shown to contain the Forssman antigen,[2] tissue and organ specific antigen,[2,3] and several enzymes as cytochrome oxidase, succinic dehydrogenase (heart muscle,[4]) and phosphatase (mouse kidney[5]).

The experiments to be described in this report indicate that these heavy materials also contain the Wassermann hapten since they react with most Wassermann positive human sera even when highly diluted, but not with Wassermann negative sera. Table I shows that the Wassermann hapten, present in saline extracts of beef heart, can be sedimented at about the same speed that is required to sediment the agents producing leukosis and sarcoma of chickens[6] and the heterogenetic and tissue and organ specific antigens. Partial sedimentation of the Wassermann antigen occurs at 15,000 r.p.m. for one-half hour, and almost complete sedimentation at 27,000 r.p.m. for one hour.

Similar results were obtained with saline extracts from human heart tested with a Wassermann positive human serum. The reacting substance, as present in

TABLE I

COMPLEMENT FIXATION TESTS WITH A WASSERMANN POSITIVE HUMAN SERUM AND FRACTIONS FROM BEEF HEART

	A	B	C	D	E
Antigen dilution	Crude extract	Sediment after centrifugation at 15,000 r.p.m.	Supernatant from B	Sediment from C after centrifugation at 27,000 r.p.m.	Supernatant from D
1/1	–	–	–	–	o
1/10	o	o	o	o	ac
1/30	o	o	o	mod	c
1/90	o	mod	ac	c	c
1/270	c	c	c	c	–
1/810	c	–	–	c	–

The sediments were suspended in saline to the original volume.

Abbreviations: o = no hemolysis, tr = trace, sl = slight, mod = moderate, st = strong, ac = almost complete, c = complete hemolysis.

The technique of the complement fixation has been described (6).

[1] These studies have been supported by grants from the International Cancer Research Foundation and The Jane Coffin Childs Memorial Fund for Medical Research.

[2] J. Furth and E. A. Kabat, SCIENCE, 91: 483, 1940.

[3] W. Henle and L. A. Chambers, SCIENCE, 92: 313, 1940.

[4] K. G. Stern, *Cold Spring Harbor Symposia on Quantitative Biology*, 7: 312, 1939.

[5] E. A. Kabat, SCIENCE, 93: 43, 1941.

[6] E. A. Kabat and J. Furth, *Exp. Med.*, 71: 55, 1940.

the crude extract, is unstable, and beef heart after autolysis for one week at room temperature contained only a small amount of this material—the complement fixing titre of such material being 1/3 as compared with 1/90 of extracts from fresh tissues.

Table II shows that heavy materials from all tissues tested gave complement fixation tests with the Wassermann positive human serum, but the antigenic titre was lower with the Wassermann positive serum than with the homologous immune serum.

TABLE II

COMPLEMENT FIXATION TESTS OF HEAVY MATERIALS FROM DIFFERENT TISSUES WITH WASSERMANN POSITIVE HUMAN SERUM AND HOMOLOGOUS IMMUNE RABBIT SERUM

Serum	Antigen mg N/ml	Heavy material: Human liver	Mouse spleen	Mouse kidney	Chicken spleen	Chicken tumor	Crude extract from chicken tumor
Wassermann positive human serum (1/100)	0.10	–	o	o	o	o	o
	0.033	o	mod	o	st	st	tr
	0.011	o	c	o	c	c	st
	0.0036	st	c	st	c	c	c
	0.0012	ac	c	c	c	c	c
Homologous immune serum (1/100)	0.011	o	o	o	o	o	o
	0.0036	o	sl	tr	o	tr	o
	0.0012	tr	ac	sl	ac	c	o

All antigen and serum controls showed complete hemolysis. The antigen was used in volumes of 0.2 ml.
Several of these sera contained Forssman antibody, but previous experiments have shown that the reaction with homologous immune serum persists after removal of the Forssman antibody from these sera. The Wassermann positive human serum used did not contain Forssman antibody.

Comparison of the reactivity of several Wassermann positive and negative human sera with the usual Warsermann antigen and with heavy material from human liver shows that the sera react more strongly with the Wassermann antigen (Table III). *E.g.,* serum No. 124 reacted with the alcoholic extract of beef heart to a serum dilution of 1/27, but with heavy material from human liver only to a dilution of 1/9. Two Wassermann positive sera failed to react with heavy material from human liver.

Table I indicates that the Wassermann hapten is contained in a complex antigen of large size. Nevertheless, immune sera obtained by immunization of rabbits with heavy material from different human, chicken and mouse tissues failed to react with alcoholic extracts from beef heart used for the routine diagnosis of syphilis. Sixteen sera prepared with high-speed deposits from human liver, kidney, spleen, from mouse spleen and kidney, and from chicken spleen and sarcoma were tested with the Wassermann antigen in serum dilution 1/20, 1/40, 1/80. Reactions with homologous antigens are shown in Table II. Only one immune serum against the heavy material from mouse kidney gave a positive complement fixation test in

TABLE III

COMPLEMENT FIXATION TESTS OF WASSERMANN POSITIVE AND NEGATIVE HUMAN SERA WITH HEAVY MATERIALS FROM HUMAN LIVER

Antigen	Serum dilution	Serum: Wassermann+ * No. 188‡	Wassermann+ * No. 124‡	Wassermann± * No. 197, 181	Wassermann – * No. 60, 61, 64	Wassermann – * No. 63	Wassermann – * No. 62
Purified alcohol extract from beef heart	1/3	–	–	0	st	0	0
	1/9	0	0	0	c	mod	0
	1/27	*0*	*0*	*mod*	*c*	*c*	*ac*
	1/81	c	tr	c	–	–	–
Heavy material from human liver	*1/3*	*mod*	*0*	*ac*	*c*	*c*	*c*
	1/9	c	0	c	c	c	c
	1/27	c	c	–	–	–	–
Serum control	1/3	ac	ac	ac	c	c	c
	1/9	c	c	c	c	c	c

* The sera so designated were obtained from the Central Laboratory of New York Hospital through the courtesy of Dr. R. G. Stillman.
‡ Similar reactions were obtained with 3 other sera.

serum dilution 1/20. The control sera were as follows: 2 sera from normal rabbits, 2 from rabbits immunized with streptococcus, 2 with pneumococcus, 1 with B mesentericus, and 2 with B subtilis. The two sera prepared by immunization with B subtilis gave a positive complement fixation test in dilution 1/20. Many rabbit sera are anti-complementary at dilutions below 1/20.

These observations are consistent with the opinion expressed by Weil and Braun[7] and by Sachs, Klopstock and Weil[8] that the Wassermann reaction results from auto-immunization to lipoidal substances liberated from tissues and activated to a complete antigen by the Spirocheta pallidum, as well as with the more recent experiments of Eagle and Hogan[9] indicating that cultured spirochetes contain material serologically related to the substance in normal tissues. Experiments are in progress to determine why Wassermann antibodies are not formed on immunization with heavy material from tissues, although this material is highly antigenic and produces Forssman and other antibodies.

Summary. The Wassermann hapten is associated with materials sedimentable at high speed present in normal and neoplastic tissues. Although these heavy materials are strongly antigenic, the immune sera produced by them in rabbits react strongly with homologous heavy materials but do not give a positive Wassermann reaction.

JACOB FURTH
ELVIN A. KABAT

DEPARTMENT OF PATHOLOGY,
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[7] E. Weil and H. Braun, *Wien Klin. Woch.*, 21: 151, 1908.
[8] H. Sachs, A. Klopstock and A. J. Weil, *Deutsch. Med. Woch.*, 51: 589, 1925.
[9] H. Eagle and R. B. Hogan, *Jour. Exp. Med.*, 71: 215, 1940.

QUANTITATIVE CHANGES IN THE SUBSTRATE-DEHYDROGENASE SYSTEM OF DROSOPHILA PUPAE DURING METAMORPHOSIS

THE rate of oxygen consumption in the pupae of holometabolous insects during metamorphosis can be expressed by a U-shaped curve. It is first high, then drops rapidly, while in the second half of metamorphosis it gradually increases again, so that before hatching of the imago, the rate often reaches or even surpasses the initial value. This was also shown to be true for *Drosophila* pupae.[1,2,3,4,5] Various theories have been put forward to account for this phenomenon.[6,7] In 1938 I suggested that the fact may be due to quantitative changes in the amount or activity of the oxygen-transferring enzyme system (Warburg-Keilin system, *i.e.*, "Atmungsferment" and cytochromes). This possibility was inferred from the effect of carbon monoxide on the oxygen consumption of *Drosophila* pupae in different stages.[8] Recently Schwan,[9] although criticizing my considerations, reaches the same conclusion. (His criticism, which seems to be insufficiently founded, should be dealt with elsewhere.)

The question still remained, if simultaneously with the changes in the oxygen-transferring system, other catalysts of the oxidation mechanism, especially the substrate-dehydrogenase system (Wieland, Thunberg)[10] will show similar quantitative alterations. In order to clear up this point, experiments were undertaken with four different stages of *Drosophila melanogaster* pupae, using the Thunberg methylene blue technique.[10] The age of the pupae was 5 to 10 hours (stage I), 25 to 30 hours (stage II), 50 to 60 hours (stage III) and 75 to 85 hours (stage IV), respectively, when reared at constant 25° C. temperature. (At this temperature the duration of the whole metamorphosis is 90 to 100 hours.) The stages were selected according to Wolsky.[5]

Preliminary experiments showed that the best results are obtained with 0.02 per cent. methylene blue solution (1 per cent. trunk solution, diluted with physiological saline, pH 6.8). From this 0.2 ccm was brought together with ten pupae in a Thunberg vacuum tube. The pupae were crushed in the methylene blue, then the tubes evacuated and put in a water bath, which was kept at a constant temperature of $20 \pm 0.1°$ C. The time was noted at which complete decoloration of the methylene blue set in.

The results revealed great differences as regards amount or activity of the dehydrogenase system in the four stages. With stage I pupae the average time required for complete decoloration was 28.0 minutes ($\pm$ 2.6 standard error, 7 experiments). In stage II the average was 67.4 min. ($\pm$ 7.2, 9 experiments), in stage III 66.1 min. ($\pm$ 6.3, 7 experiments) and finally in stage IV 25.6 min. ($\pm$ 2.4, 8 experiments). As these figures show, the differences between stage I and II, *i.e.*, 39.4 min. ($\pm$ 7.7 standard error) and between stages III and IV (40.5 ± 6.7), are statistically significant. It is interesting to note that in stages II and III the decoloration time is more than twice the time observed in stages I and IV. The data for oxygen consumption are, according to Wolsky,[5] 4.66 cmm per hour per 1 mg dry weight in stage I, 2.23 cmm in stage II, 2.32 cmm in stage III and 5.05 cmm in stage IV. These data, when compared with the results of the decoloration experiments, show a striking similarity as regards the magnitude of differences. Thus the graphic representation of the results of the decoloration experiments gives a U-shaped curve, which is very similar to that obtained for oxygen consumption during metamorphosis (see Fig. 1).

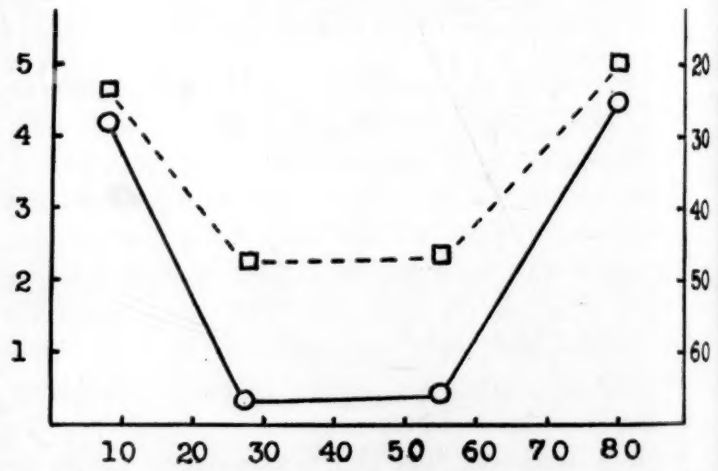

FIG. 1. Graph showing changes in oxygen consumption (squares, connected with broken line) and in substrate-dehydrogenase activity (circles, connected with full line) during metamorphosis. Abscissa: pupal age in hours. Ordinate (left): oxygen consumption in cmm per hour, per 1 mg dry weight. Ordinate (right): time in minutes, necessary to decolorize 0.2 ccm 0.02 per cent. methylene blue, containing 10 pupae.

The results can not be due to exhaustion of hydrogen-donator substances in the pupae in stages II and III. The addition of potassium succinate (0.4 per cent.), as extra donator, to the reaction mixture does not alter the results, and the differences between the four stages

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[2] M. R. Clare, *Biol. Bull. Woods Hole*, 49: 440, 1925.
[3] D. F. Poulson, *Zeits. vergl. Physiol.*, 22: 466, 1935.
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[9] H. Schwan, *Ark. Zool.*, 32: 1, 1940.
[10] T. Thunberg, *Quart. Rev. Biol.*, 5: 318, 1930.

remain unchanged. This means that the dehydrogenase system is saturated with substrate during the whole period of metamorphosis. From the experiments reported here, it is clear that the substrate dehydrogenase system of *Drosophila* pupae undergoes quantitative changes during metamorphosis, which run parallel with those observed earlier in the oxygen-transferring system and which are manifested in the oxygen consumption of the pupae in different stages.

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OZONIZATION OF o-XYLENE AND 1,2,4-TRIMETHYLBENZENE[1]

LEVINE and Cole[2] found that *o*-xylene on ozonization affords products evidently arising from both of the two possible Kekulé forms of the hydrocarbon, but they presented no data concerning the yields of the three substances which they isolated. A reinvestigation of this reaction in our laboratory from the analytical point of view has been completed and will be described in detail in a paper which is being prepared for publication in the *Recueil des Travaux Chimiques des Pays-Bas*. As noted in a preliminary report of some of the experiments,[3] our method of following the course of the reaction consists in converting the products of ozonization into the oximes and determining the composition of the oxime mixture by a special analytical method.

If each of the two Kekulé forms contributes 50 per cent. to the structure of *o*-xylene, there should be formed 1 mole of dimethylglyoxal, 2 moles of methylglyoxal and 3 moles of glyoxal from 2 moles of *o*-xylene. We have transformed these decomposition products into the corresponding oximes and obtained the total oxime mixture in yields of from 20 to 25 per cent. of the theoretical amount calculated on *o*-xylene. The above theoretical ratio of the free carbonyl compounds would correspond to an oxime mixture of the following composition: dimethylglyoxime, 20 per cent.; methylglyoxime, 35 per cent.; glyoxime, 44 per cent. As a mean of six ozonization experiments, we found the ratio: dimethylglyoxime, 20.7 per cent.; methylglyoxal, 34.2 per cent.; glyoxime, 44 per cent. The accordance with the theoretical values seems better than it actually is, because the separate experiments show deviations of from 3 to 7 per cent. from the theoretical values. Considering the experimental difficulties, the accordance between experiment and theory is satisfying.

We have also investigated the ozonization of 1,2,4-trimethylbenzene. In this case, if the two resonating Kekulé forms each contribute 50 per cent. to the structure of the hydrocarbon, 2 moles of 1,2,4-trimethylbenzene should provide 1 mole of dimethylglyoxal, 4 moles of methylglyoxal and 1 mole of glyoxal, and the composition of the mixture of oximes should be: dimethylglyoxime, 18.9 per cent.; methylglyoxime, 66.7 per cent.; glyoxime, 14.4 per cent. As a mean of two ozonization experiments, we found the following percentages: dimethylglyoxime, 17.9 per cent.; methylglyoxime, 66.2 per cent.; glyoxime, 14.2 per cent. The accordance with the theoretical ratio is very good. In this case the quantity of oximes recovered amounted to 15 per cent. of the theoretical yield.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

PRESERVATION OF BIOLOGICAL SPECIMENS WITH ISOBUTYL METHACRYLATE POLYMER

DURING the last few years several articles have been published describing various methods of preserving biological material by the methacrylate resins. Dr. J. H. Hibben[1] described a method of allowing the plastic to polymerize around the object to be preserved. Dr. H. G. Knight[2] called attention to the expense and difficulties of this method and Professor E. C. Cole[3] mentioned the possibility of imbedding objects in a solution of methyl methacrylate polymer dissolved in chloroform, but stated that he did not get satisfactory results.

Some months ago while attempting to preserve the color patterns of *Chorthippus longicornis* for genetic studies, the writer tried dipping the grasshoppers in a solution of isobutyl methacrylate polymer dissolved in toluene. The grasshoppers were first injected with various preservatives, pinned and then dipped in a solution containing 10 gm of the polymer to 100 cc of toluene, and allowed to dry. By repeated dippings

[1] This communication is constructed from data sent to me by Professor J. P. Wibaut in a letter of February 24, 1941, with the request that I arrange for its publication in SCIENCE. Professor Wibaut states, "I would appreciate very much if our results could be made available to American scientists in this way, as it may take some time before our complete paper will be published and even then it may not be available to the chemists in your country."—L. F. Fieser, Harvard University.

[2] A. A. Levine and A. G. Cole, *Jour. Am. Chem. Soc.*, 54: 338, 1932.

[3] J. P. Wibaut and P. W. Haayman, *Nature*, 144: 290, 1939.

[1] J. H. Hibben, SCIENCE, 86: 247–248, 1937.

[2] H. G. Knight, SCIENCE, 86: 333–334, 1937.

[3] E. C. Cole, SCIENCE, 87: 396–398, 1938.

a coat approximately 1/16 of an inch thick was placed on the insects. When the abdomen was injected with 2 per cent. formaldehyde there was a slight fading, but recently, at the suggestion of Dr. C. E. McClung, ordinary white Karo syrup has been injected into the abdomen and so far there has been no fading. Every color is life-like and natural. As the methacrylate resin dries, however, there is a slight shrinkage. Wings of grasshoppers may be pinned out and painted with the resinous solution, adding successive coats until the desired thickness is obtained. Each coat must be thoroughly dry before the next coat is applied or the succeeding coat will soften the previous coat and allow the wing to fold. The wings may be allowed to dry for two or three days in a stretched position and then painted or they may be painted immediately after stretching if due care is taken to prevent the wings from being cemented to the stretching board or pins. In order to do this, best results were obtained by painting the dorsum of the body and the medial halves of the superior surfaces of the wings, allowing these areas to dry and then painting the lateral halves of the superior surfaces. After that coat was dry the ventral surfaces of the body and wings were painted. Then alternate coats were applied to the dorsal and ventral surfaces until they had a coating about one sixteenth of an inch thick.

Butterflies have been preserved in this manner. Except for the fact that the opaque scales are rendered translucent, the color pattern is preserved perfectly, and they may be examined with almost complete disregard for their fragility; in fact, several of the butterflies have been worn as ornaments, their glass-like finish giving them the appearance of imitations.

Frogs up to six inches in length have been preserved by dipping them in the resinous solution. Best results have been obtained by injecting the coelomic spaces and the muscles of the thigh and calf of the frog with a solution of sodium benzoate (one part saturated solution of sodium benzoate to three parts distilled water), then soaking them for fifteen minutes in a 2 per cent. formaldehyde solution before dipping them in the methacrylate solution. If the frogs are alternately dipped and dried until they have a coating from one sixteenth to one eighth of an inch thick there is no appreciable shrinkage. Good results have also been obtained by using 2 per cent. formaldehyde for injection purposes.

Each particular kind of material has to be treated in a manner suitable for its own needs. Leaves dried under pressure for two days and then dipped in this plastic solution have kept their color without distortion. Furthermore, fragile bones soaked in a solution of isobutyl methacrylate polymer have been strengthened until they can be handled without undue danger of damage.

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A SIMPLE IMPROVEMENT IN THE FROG WEB CIRCULATION DEMONSTRATION

So often is the demonstration of the circulation in the web of the frog's foot used in biology classes that a simple improvement in the usual technique is worthy of mention here.

Recently we found it necessary to take photomicrographs of the melanophores in the frog web to record changes in size and shape. In order to produce a plane field such that the edges of the preparation would be in focus simultaneously with the center the idea was conceived of using a small plate of glass placed under the web between two toes. An ordinary microscope slide was cut into triangles, the apices of which were angles varying from 40° to 60°. By cutting diagonally across the slide these triangles had an altitude of one inch. The sharp edges were then rubbed smooth on a piece of emery cloth.

After the frog's toes were spread apart in the usual manner across an opening in the frog board a glass triangle was slipped between two toes and under the web. The glass triangle adheres tightly to the lower surface of the web once it comes in contact with it and the result is a plane surface which lends itself ideally for microscopic observation. Photomicrographs can be made of an area of the web with the entire optical field in focus. Observations of the blood flow are greatly improved. Also it has been found that the web does not become too dry if left in this condition for at least an hour which obviates adding water to the surface which in turn changes the focus of the microscope.

The simple addition of a glass triangle (which is very easily made) so improves the aspect of the web circulation that it is well worth trying by any one having to set up such a preparation.

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